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# Timber Volumes in the Mangrove Forests of Pohnpei, Federated States of Micronesia

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## INTRODUCTION

Pohnpei is a high island in the State of Pohnpei, Federated States of Micronesia. It is located in the Eastern Caroline Islands (lat. 6° 54' N., long. 158° 14' E.), about 4983 km southwest of Hawaii (Ashby 1983). The island has a total area of 35,488 ha, of which 5525 ha are estimated to be mangrove forests (MacLean and others 1986).

The mangrove resource provides many important products and functions: habitat for local flora and fauna; fisheries; a source of firewood, craftwood, and construction materials; and an aid in "filtering" runoff from the eroding uplands of the island. The large areas and diverse uses of mangroves have resulted in a variety of interests ranging from preservation to commercial exploitation.

As a follow-up to vegetation mapping and a generalized volumetric inventory of Pohnpei conducted in 1984 (MacLean and others 1986), the chief forester of Pohnpei State requested technical assistance from the Forest Service, U.S. Department of Agriculture, to perform a more intensive inventory of the mangrove resources. The resulting information was to be used in local planning efforts.

This bulletin reports the results of a volumetric inventory of the mangrove resources of Pohnpei, conducted by the Forest Service's Pacific Southwest Forest and Range Experiment Station and the State of Pohnpei's Forestry Division. The results of this inventory are proving valuable to the Pohnpei State Legislature as they consider legislation that would establish mangrove forest reserves.

## METHODS

Data from earlier vegetation mapping and inventory efforts were used to determine the size and intensity of the inventory sample (MacLean and others 1986). Three strata of mangrove forests had been identified:

0—trees are generally of small stature, usually having d.b.h. (diameters at breast height) of less than 12.0 cm.

1—trees are generally at least 12 cm in d.b.h., but less than 30 cm.

2—trees have a d.b.h. of 30 cm or greater.

The two strata with larger trees, 1 and 2, were selected for sampling. The area of stratum 1 was 3049 ha, and of stratum 2 was 1806 ha. The starting area for stratum 1 was 3440 ha, but the area was reduced during the inventory to account for field corrections.

The Pohnpei Forestry Division requested that estimates of mean volume be within 20 percent at the 95 percent probability level. Starting with a coefficient of variation calculated from data collected during the general volumetric inventory, 42 plots were needed in each stratum to meet the desired precision level (Dilworth 1973).

Plot locations were established initially on base maps, using a grid design with a random start, and were then transferred to aerial photographs for field use. Field adjustments for plots falling on the borders of mangrove types and corrections for stands that were incorrectly typed on the initial maps resulted in the establishment of 39 plots in stratum 1 and 38 in stratum 2.

Variable radius plots with a basal area factor prism of metric 7 were selected. Tree characteristics measured were diameters at the base, breast height, crotch bases, taper changes, and branches for each tree; and heights for bole, crotch, and branch sections. Measurements were not reduced for poor form or rot.

The microcomputer program used to calculate the tree volumes and the confidence limits treats bole (main stem) sections as conic sections, crotch (forked) segments as cylindrical sections, and branches as cylinders based on an average mid diameter (Imoto 1984).

## RESULTS

Total mangrove volume was estimated at 698,380 m<sup>3</sup> (table 1). Stratum 2 with its larger trees had an average volume of just over twice that of stratum 1 (table 2).

Almost 85 percent of the total gross volume lies in the boles of the trees. The crotch segments account for only 4 percent, and branch segments for the remaining 11 percent.

Mangrove species identified in strata 1 and 2 were these (Fosberg 1979):

| Scientific name and author              | Family         |
|---|----------------|
| <i>Bruguiera gymnorhiza</i> (L.) Lam.   | Rhizophoraceae |
| <i>Lumnitzera littorea</i> (Jack) Voigt | Combretaceae   |
| <i>Rhizophora apiculata</i> Bl.         | Rhizophoraceae |
| <i>Rhizophora mucronata</i> Lam.        | Rhizophoraceae |
| <i>Sonneratia alba</i> J.E. Smith       | Sonneratiaceae |
| <i>Xylocarpus granatum</i> Koen.        | Meliaceae      |

Table 1—Total mangrove volume (m<sup>3</sup>) by tree segment and stratum, Pohnpei, 1984

| Stratum | Bole    | Crotch | Branch | Total   |
|---------|---------|--------|--------|---------|
| 1       | 257,318 | 12,773 | 35,668 | 305,759 |
| 2       | 332,838 | 14,394 | 45,389 | 392,621 |
| Total   | 590,156 | 27,167 | 81,057 | 698,380 |

Table 2—Average gross volumes of mangroves on Pohnpei, 1984, by species, tree segment, and stratum<sup>1</sup>

| Species and stratum         | Bole                    | Crotch | Branch | Total | Percent of stratum |
|-----------------------------|-------------------------|--------|--------|-------|--------------------|
|                             | <i>m<sup>3</sup>/ha</i> |        |        |       |                    |
| Stratum 1                   |                         |        |        |       |                    |
| <i>Rhizophora apiculata</i> | 28.4                    | 0.6    | 1.3    | 30.3  | 30.18              |
| <i>Rhizophora mucronata</i> | 8.3                     | 0.0    | 0.0    | 8.3   | 8.27               |
| <i>Xylocarpus granatum</i>  | 10.8                    | 1.1    | 2.3    | 14.2  | 14.14              |
| <i>Sonneratia alba</i>      | 9.6                     | 1.3    | 4.8    | 15.8  | 15.74              |
| <i>Bruguiera gymnorhiza</i> | 23.0                    | 0.8    | 1.8    | 25.6  | 25.50              |
| <i>Lumnitzera littorea</i>  | 4.4                     | 0.3    | 1.5    | 6.2   | 6.18               |
| Total, stratum 1            | 84.4                    | 4.2    | 11.7   | 100.3 | —                  |
| Stratum 2                   |                         |        |        |       |                    |
| <i>Rhizophora apiculata</i> | 27.5                    | 0.6    | 7.6    | 35.8  | 15.97              |
| <i>Rhizophora mucronata</i> | 11.3                    | 0.2    | 0.4    | 11.9  | 5.31               |
| <i>Xylocarpus granatum</i>  | 31.7                    | 2.2    | 7.0    | 40.9  | 18.24              |
| <i>Sonneratia alba</i>      | 75.8                    | 4.9    | 14.9   | 95.6  | 42.64              |
| <i>Bruguiera gymnorhiza</i> | 37.6                    | 0.6    | 1.8    | 40.0  | 17.84              |
| Total, stratum 2            | 184.0                   | 8.0    | 25.1   | 217.0 | —                  |

<sup>1</sup>Columns may not add, due to rounding.

The species with the majority of volume differs in each stratum. *Rhizophora apiculata* volume predominates in stratum 1, while *Sonneratia alba* predominates in stratum 2. *Xylocarpus granatum*, a favored species for craftwood and lumber, is second in volume only to *Sonneratia* in stratum 2, but ranks fourth in stratum 1.

Sampling errors were well within the precision goals of the project:

| Volume and error                            | Stratum 1 | Stratum 2 |
|---|-----------|-----------|
| Average basal area . . . m <sup>2</sup> /ha | 20.4      | 32.1      |
| Standard deviation . . . . . m <sup>2</sup> | 30.6      | 53.6      |
| Sampling error . . . . . pct                | 12.1      | 9.9       |
| Coefficient of variation . . . pct          | 75.5      | 61.0      |

should be aware of them. In some cases, such knowledge might allow for the establishment of management practices to influence ultimate species predominance.

The volumes cited do not include the smallest mangrove trees, those with d.b.h. less than 12.0 cm (stratum 0). However, these stands are a vital component of the mangrove resource. They are commonly the outer edges of the mangrove forests and have important natural functions of their own, often supporting delicate ecosystems both above and below the surface of the water.

While this bulletin addresses tree volumes, the overall biological importance of these mangrove forests cannot be overemphasized. The wood value is only one small component of their overall worth to the people of Pohnpei. Future management decisions affecting the mangrove forests must consider the value of the resource as a whole.

## DISCUSSION AND CONCLUSIONS

While the volume of wood appears to be considerable, no information on growth rates is available. Stratum 2 may be older than stratum 1 or 0. However, for instance, the size differences may reflect site factors rather than age. Without growth information, one cannot be sure which explanation is correct. Growth and mortality studies are needed, especially before any significant harvesting is attempted.

Little is known about the successional trends of the various mangrove species. Different species tended to predominate in the two strata. Whether this is due to successional or other factors deserves investigation, especially given the differences in relative values between species. If abiotic or biotic factors favor certain species over others, planners and managers

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The mangrove resource is of great value to Pohnpei. A volumetric inventory of 4855 ha of mangroves on the island was conducted in 1984. Two size strata were sampled: trees with diameters at breast height (d.b.h.) of 30 cm or greater, and smaller trees with d.b.h. of at least 12.0 cm but less than 30 cm. Gross tree volumes and statistical confidence limits were determined with a microcomputer program. Outputs were gross volumes by stratum, tree, tree segment, and species. Total volume estimated was 698,380 m<sup>3</sup>. Almost 85 percent of this volume was in the boles of the trees. Different species tended to predominate in the two strata.

*Retrieval Terms:* inventory, mangroves, timber volumes, Pohnpei, Micronesia

